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(64) Electronic level

(57) A level comprises a body portion (1) having a flat surface (2) for placing on a surface to be tested, means carried in or on the body portion and responsive to a deviation from the horizontal and/or the vertical plane and having associated therewith means for generating a signal corresponding to the position of the deviation responsive means and display means (4) responsive to the signal for indicating deviation and/or lack of deviation and, preferably, for indicating the degree of any deviation.

The signal generating means preferably comprises at least one light source and at least one detector (11) and the means responsive to deviation comprises a quadrant (13) of opaque material mounted for free pivotal movement between at least one light source and at least three photo detectors (11) arranged such that when the level is exactly horizontal or vertical the centre detector (11b) is half masked by the quadrant from the light source and of the two detectors (11a, 11c) on each side of the centre detector (11b) one is fully marked and the other fully exposed to the light source.

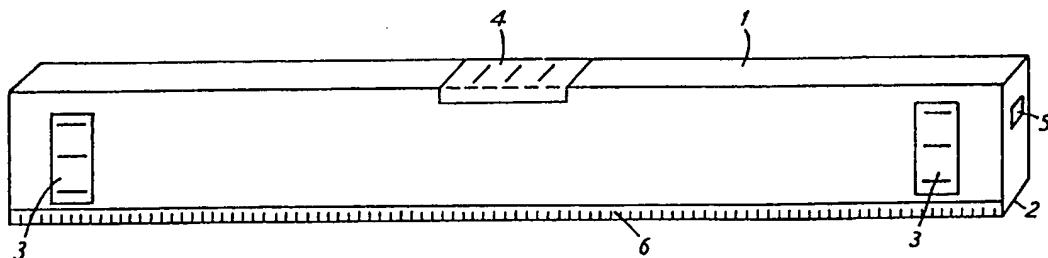


FIG. 1

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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

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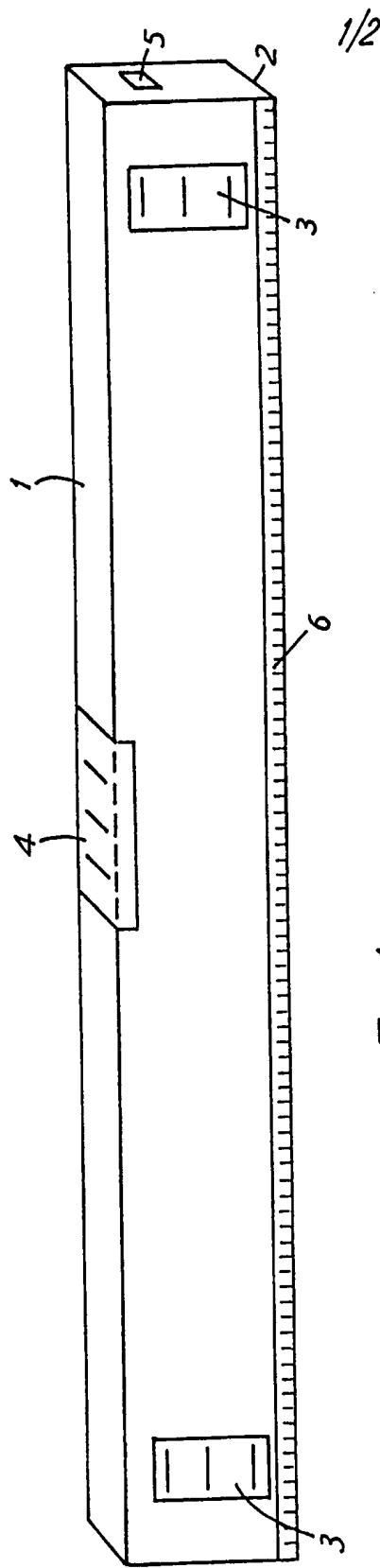
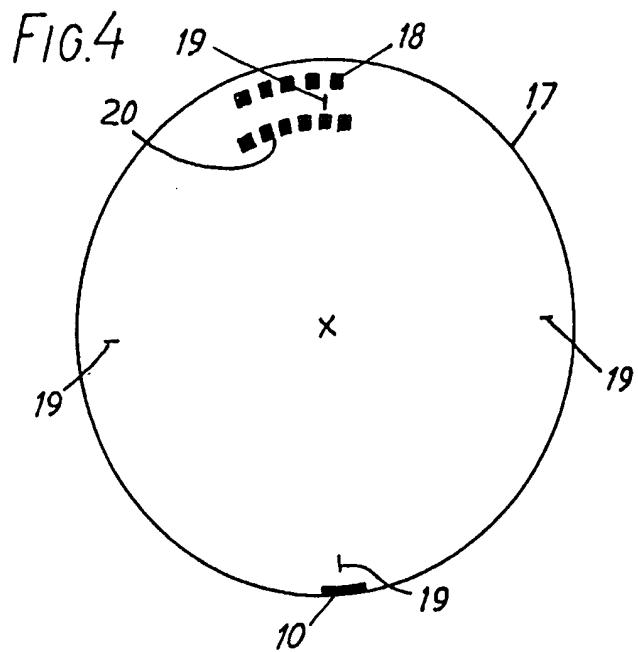
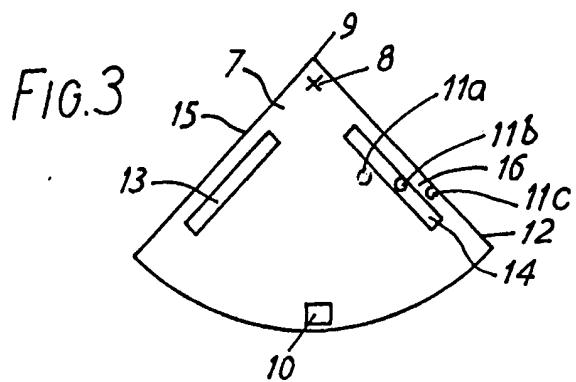
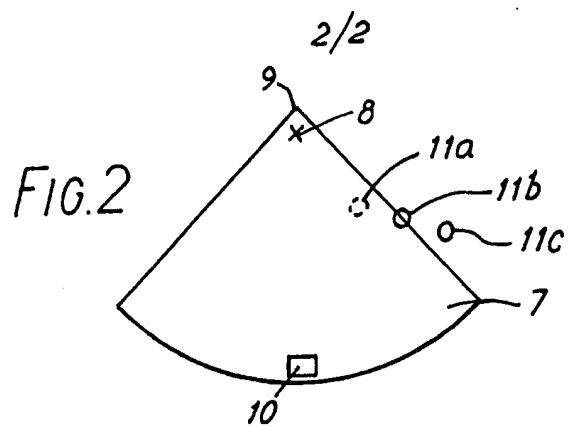


FIG. 1

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SPECIFICATION**Electronic level**

5 Levels have been used in, for example, the building industry for many years to provide a facility for ensuring that a surface is built, laid, drawn etc., to a correct angle. Until now levels have operated by means of an air
 10 bubble in a liquid (usually alcohol), the position of the former indicating the horizontality or verticality of the surface; levels of this type are commonly called "spirit levels".

Although recognised as being the normally used means for determining the inclination of a surface, spirit levels are not generally considered to be particularly accurate as they rely on a visual interpretation of bubble position by the user and this can be affected by errors, 20 such as parallax errors and the accuracy of the users vision.

This invention provides a level which operates electronically.

According to the present invention a level 25 comprises a body portion having a flat surface for placing on a surface to be tested, means carried in or on the body portion and responsive to a deviation from the horizontal and/or the vertical plane and having associated therewith means for generating a signal corresponding to the position of the deviation responsive means, and display means responsive to the signal for indicating deviation and/or lack of deviation and, preferably, for 35 indicating the degree of any deviation.

In addition, the level of the invention may contain a device which will indicate the actual angle of the level to the vertical or horizontal axis at any one time.

40 The signal generating means may comprise any means that in conjunction with the deviation responsive means can detect deviation from a horizontal and/or vertical plane and generate a signal indicating whether deviation 45 exists and, preferably, the extent of such deviation.

The signal generating means may, for example, comprise a light source, preferably a multiple light source, and a detector, for 50 example, a photo-responsive device, together with means responsive to deviation from the horizontal and/or vertical planes interposed between the source and the detector whereby the amount of light reaching the detector from 55 the source is varied with the deviation.

The means responsive to deviation may, for example, comprise a simple pendulum or like pivoted arrangement or trapped bubble or ball of liquid or solid material arranged between 60 the light source and the detector.

In a simple form of the level the means responsive to deviation comprises a quadrant of opaque material mounted for free pivotal movement between a light source and three 65 photo detectors arranged in line such that

when the level is exactly horizontal or vertical the centre detector is half masked by the quadrant from the light source and of the other two detectors one is fully masked and the other fully exposed to the light source.

70 When the level deviates from the horizontal or vertical different permutations of the detectors are exposed to or masked from the light source depending upon the extent and direction of the deviation. Alternatively, the quadrant may be provided with at least one radial slot arranged such that in the exactly horizontal or vertical orientation, the middle one of the three detectors only is exposed to the 75 source through the slot. In other orientations others of the three detectors will be exposed through the slot or may be exposed beyond the boundaries of the quadrant or totally masked by the quadrant in the case of higher deviations.

80 In order that both horizontality and verticality can be detected the quadrant preferably has two slots one adjacent each radial edge and having their axes exactly perpendicular to 85 each other.

90 Instead of a quadrant with two radial slots there may be provided a circular disc pivoted at its centre with four radial slots arranged precisely at 90° to each other. This allows the 95 level to be used in any orientation with a single three detector array.

The quadrant or disc, should of course be biased, for example, by weighting, so that it always hangs in the same vertical plane 100 through the pivot point. Further the quadrant or disc must swing freely in its pivot in a virtually frictionless bearing, for example, a jewelled bearing. Because of the conditions in which levels are normally used in the building 105 industry or the like the arrangement should preferably be substantially shock proof and maintenance free. For protection from dust and moisture etc, the deviation responsive means and the associated electronic circuitry 110 will normally be enclosed within a casing, for example, by encapsulation in a potting resin.

The quadrant or disc may be made of any rigid, robust, opaque material, for example, aluminium or a suitable plastics material and 115 may be weighted, for example, with lead or steel.

120 It will be appreciated that instead of having a plurality of detectors it is of course possible to have a single detector and a plurality of light sources. Further although mention has been made of devices with three detectors this is merely of convenience in a simple form of level since it gives a reference point for telling the direction of deviation from a readily detected position of exact horizontality or verticality. A very simple device may simply require a single light source and detector and more sophisticated devices may include more than three sources and/or detectors.

130 The light source(s) is preferably a solid state

infra-red device because of the low power consumption and the long term life of such devices. The detector(s) is preferably a photo-electric diode(s).

- 5 In the simplest form of the level a display indicating which of the detectors is being activated by the light source will show the orientation of the level. Alternatively, the display may be a digital LED or LCD display or a graduated read-out and, in addition, it may be desirable to provide audible indicating means.
- 10 In a more sophisticated form of the level, instead of employing a simple pivoted quadrant or disc the level can incorporate a shaft encoder arrangement for detecting the exact orientation of the level. In such a case the level preferably includes a digital LED or LCD display indicating the exact deviation of the level from the horizontal or vertical.
- 15 The level preferably also includes test facilities to show that the electronics are functioning correctly and/or that the power source is functioning correctly.
- 20 The invention will now be described in greater detail by way of example with reference to the drawings in which Fig 1 is a schematic view of one form of level according to the invention and Figs 2 to 4 show three different forms of detecting means for use in 30 the level shown in Fig.1.

As shown in Fig. 1 one form of level according to the invention comprises a body member 1 having an exactly flat base 2 and having an indicator light display 3 towards each end on one or both sides, a central light display 4 on its top surface and an on/off switch 5 at one end. The edge 6 of the base is marked out as a metric measure.

The level may be made, for example, from the conventional materials used for the body 1 and base 2 of the hitherto known spirit levels or from any other suitable material.

As shown in Fig. 2, within the body member 1 is mounted a quadrant 7 of aluminium pivoted in a jewelled bearing 8 at a point towards its apex 9 and being weighted by a lead insert 10 so that it always hangs in the same vertical plane through the pivot 8. The angle of the apex 9 of the quadrant 7 is 50 exactly 90° and the side edges are exactly straight.

A battery powered light source (not shown) is positioned on one side of the quadrant 7 and three photo detectors 11a, b, c are arranged in a line cutting one edge 12 of the quadrant 7 such that in the null position of exact horizontality the centre detector 11b is half masked from the light source, the detector 11a being wholly masked and the detector 11c being wholly exposed. In the null position of exact verticality the quadrant 7 pivots to a position in which edge 13 cuts the line of the detectors 11, the detector 11b is again half masked, the detector 11a is exposed and 65 detector 11c is wholly masked.

In the null position the detectors 11 generate a signal which is displayed either on display 3 or display 4 depending on whether the level is used in the horizontal or vertical mode. The displays 3, 4 indicate which detectors are masked and which are exposed or partly exposed. With deviation from the horizontal, if the right hand end of the level is high, detector 11b becomes wholly exposed

- 70 and eventually detector 11a becomes exposed. With the left hand end high detector 11b becomes wholly masked and eventually all three detectors 11 are masked.

The arrangement shown in Fig. 3 is basically the same as that of Fig. 2, but to avoid any problems that might arise from having a partly masked detector 11b at the null point, the quadrant 7 has two radial slots 14, 15 adjacent to and spaced from its edges 12, 13. 80 in this arrangement, at the null point for horizontal measurement detector 11b is exposed through the slot 14, detector 11a is masked by the main body of the quadrant 7 and detector 11c is masked by the strip of 85 material 16 between the slot 14 and edge 12. With the right hand end high detector 11b is masked by strip 16, detector 11a is exposed through the slot 14 and detector 11c is exposed beyond the edge 12 of the quadrant 7. With the left hand end high detector 95 11c is exposed through slot 14 and detectors 11a and 11b are masked by the body of the quadrant 7.

Again, by indicating which detectors 11 are exposed to the light source deviation from the horizontal or vertical can be indicated on the displays 3 or 4 respectively.

If it desired that the level can be used with base 2 upper most a quadrant can be replaced by a circular disk pivoted at its centre and having four radial slots exactly at right angles. In this case if only 3 detectors 11 are used, for much of the time, in conditions of non-horizontality or non-verticality all three 105 detectors 11 will be masked by the disc and accordingly it is preferred that a larger number of detectors is used so that one detector is always exposed through a slot. With this arrangement the level can be calibrated so 110 that the particular source that is exposed gives a direct angular measure of the deviation from the horizontal or vertical which can be expressed in degrees on a digital display.

In the arrangement shown in Fig. 4, the 120 pivoting quadrant or disc is replaced by a shaft encoder. In a simple form the shaft encoder may comprise a pivoted transparent disc 17, for example, of glass or Mellinex, having a circumferential track 18 of spaced 125 black bars, normally produced photographically. An index track 19 comprising four single black bars spaced at 90° intervals lies inside the first track 18 and a third track 20 of spaced black bars identical to the first track 130 but out of phase 180° lies inside the index

track 19. The three tracks 18, 19 and 20 are each straddled by a detector system comprising a light source and a detector coupled to an electronic counter. The disc 17 is 5 weighted to ensure that in the null position two of the index bars are exactly vertical and two are exactly horizontal. The detectors are connected to an electronic counter which counts the number of bars of track 18 that 10 pass the detector using the index track 19 to establish a starting point. Track 20 provides means for detecting the direction of rotation of the disc 17.

With the arrangement shown in Fig. 4 the 15 actual angle of the level can be established very accurately and can be indicated as a digital display.

Preferably in this arrangement there is provided switching means to enable angle measurement from either the horizontal or the 20 vertical to be made.

CLAIMS

1. A level comprising a body portion having 25 a flat surface for placing on a surface to be tested, means carried in or on the body portion and responsive to a deviation from the horizontal and/or the vertical plane and having associated therewith means for generating 30 a signal corresponding to the position of the deviation responsive means and display means responsive to the signal for indicating deviation and/or lack of deviation and, preferably, for indicating the degree of any deviation.
2. A level according to Claim 1, including 35 means for producing a direct readout of the angular inclination of the level.
3. A level according to Claim 1 or Claim 2, 40 wherein the signal generating means comprises at least one light source and at least one detector, together with means responsive to deviation interposed between the source and the detector whereby the light reaching 45 the detector from the source is varied with the deviation.
4. A level according to Claim 3, wherein 50 the means responsive to deviation comprises a pivoted body or a trapped bubble or ball of liquid or solid material arranged between the light source and the detector.
5. A level according to Claim 4, wherein 55 the means responsive to deviation comprises a quadrant of opaque material mounted for free pivotal movement between at least one light source and at least three photo detectors arranged such that when the level is exactly horizontal or vertical the centre detector is half masked by the quadrant from the light source
- 60 and of the two detectors on each side of the centre detector, one is fully masked and the other fully exposed to the light source.
6. A level according to Claim 4, wherein 65 the means responsive to deviation comprises a quadrant, semi-circle or disc of opaque ma-

terial mounted for free pivotal movement between a light source and at least three photo-detectors, the quadrant, semi-circle or disc having radial slots arranged such that when the level is exactly horizontal or exactly vertical the centre detector is exposed to the light source through a slot and the two detectors on each side of the centre detector are masked.

- 70 7. A level according to Claim 5 or Claim 6, wherein instead of, or in addition to, there being a plurality of detectors there is provided a plurality of light sources which are masked or exposed as the deviation responsive means
- 80 adopts a position indicative of the position of the level.
8. A level according to Claim 4, wherein the deviation responsive means comprises a shaft encoder arrangement for detecting the exact inclination of the level.
9. A level according to Claim 1, substantially as described herein with reference to Fig. 1 and any one of Figs. 2 to 4 of the drawings.

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